REMARKS/ARGUMENTS

Claims 21- 55 are pending in the application. Claims 48-55 have been withdrawn from consideration.

In an Office Action dated December 1, 2004, claims 21-25, 27-36, 38-44, and 46 were rejected, and claims 26, 35, 37, 45 and 47 were objected to. In light of the previous amendments, the specification, and the following remarks, the applicant submits that the claims are allowable over the cited art and the rejections should be withdrawn.

Rejections under 35 USC § 132

The proposed amendments to claims 21-26, 28-30, 32-35, and 47 were rejected as introducing new subject matter into the disclosure. These claims were amended describe the container as "shatterable". The office action contends that the "shatterable" limitation is not supported by the original disclosure and thus changes the scope of the application.

The applicant respectfully traverses this rejection. The limitation of shatterable is not new subject matter, as the shatterable properties of the container are specifically disclosed throughout the specification. For example:

- The panels can be formed to totally fracture in a more complete manner than the remainder of the panel, reduce inhibition of the desired crack propagation, promote panel **shattering**, and improve powder release characteristics. Container "panel **shattering** and powder release characteristics after impact" are specifically identified as "enhanced design features". (Summary of the Invention, page 8, lines 5-8).
- The panel disks of Figure 3 are specifically described as **shattering** to discharge fire extinguishing chemical (Detailed Description, page 11, lines 12-13).

The specification also indirectly discloses the shatterable characteristic as claimed. A common definition of shatter is "to break at once into pieces" (Merriam-Webster Online, *at* http://www.m-w.com). Breaking the container into multiple pieces at once is clearly disclosed in the specification. For example:

- One of the disclosed features is to "maximize outer face breakup" of the container panel (page 6, line 18).
- The container panel may be configured to "totally fracture" (page 8, line 3-4).
- The panel may be configured to crack and rupture like "glass windows that break out in a house or a car that is on fire" (page 13, lines 8-9).

Further, the original specification describes materials for forming the container that are known to shatter. For example, "brittle plastics such as acrylic" may be "ideal" for the outer material of a panel container (page 13, lines 10). This is because acrylic is "more prone to total breakage when impacted" (page 15, line 12). Acrylic is well established as a shatterable material (Keith Seyffarth, *Glass vs. Acrylic: The Differences Between and the Debate About Glass Aquariums and Acrylic Aquariums*, at http://honors.montana.edu/~weif/firsttank/tanktype.phtml (last visited May 31, 2005); *Sign Grade High-Performance Polycarbonate Sheet*, Sheffield Plastics, Inc., *at* http://www.sdplastics.com/ref.html (last visited May 31, 2005)). Also, acrylic is known to have a low impact resistance when compared to other plastics materials. (Tami C. Voss, *See-Through Plastic Installation Guidelines*, IAPD Magazine, (July 2004) *available at* http://www.theiapdmagazine.com/pdf/magazine-archives/195.pdf ; W.A. Whitaker III, *Acrylic Polymers*: *A Clear Focus*, Medical Plastics and Biomaterials Magazine, (January 1996) *at* http://www.devicelink.com/mpb/archive/96/01/001.html). Acrylic also has a relatively low Izod Impact Strength, 0.8 – 2.5 ft-lb/in, when compared to other plastics such as polyurethane, 22.0 ft-lb/in (Property Comparisons of Selected Engineering Thermoplastics, *at* http://www.dow.com/webapps/lit/litorder.asp?filepath=sal/pdfs/noreg/302-00077.pdf&pdf=true (last visited May 31, 2005). Thus, the specification clearly discloses that the container may comprise brittle plastics susceptible to shattering as described in the claims.

In sum, contrary to the assertions of the office action, the original disclosure of the specification both expressly and indirectly discloses the shatterable limitation.

Therefore, the applicant respectfully submits that the rejections of the amendments are inappropriate and should be withdrawn.

Rejections under 35 USC § 112

Claims 21-47 stand rejected under 35 U.S.C. § 112 as failing to comply with the written description requirement. The office action alleges that the claims contain subject matter that was not described in the specification in such a way as to reasonably convey, at the time the application was filed, that the inventor had possession of the claimed invention.

The applicant respectfully traverses these rejections. As discussed above, the limitation of "shatterable" was amply disclosed in the specification. The original disclosure of the application employs the word "shatter" to describe the operation of the embodiments, includes descriptions of "shatterable" (e.g., maximize breakup, totally fracture, analogies to glass windows), and discloses forming the container of brittle materials, such as acrylic, that are known to shatter. Therefore, no new subject matter was added, and the scope of the invention did not change as a result of amending the claims to include the word shatterable. Thus, the applicant respectfully submits that the rejections of the claims are improper and should be withdrawn.

Rejections under 35 USC § 102(b)

Claims 21, 22, 27-31, 36, 38-41, and 46 were rejected as being anticipated by U.S. Patent No. 4,121,666 to Rozniecki. The office action asserts that the Rozniecki reference discloses each and every element and limitation in the rejected claim. The Rozniecki reference does not, however, disclose a shatterable container as required by claims 21, 30, and 40. On the contrary, the panel of Rozniecki reference comprises "a material that will not easily fragment" (col.3, line 20). Further, the Rozniecki reference indicates that the "wall 40 [of the panel] should not splinter into fragments" (col.3, lines 21-22). Thus, the Rozniecki reference specifically teaches away from the claimed invention.

Claims 21-23, 27-32, 36, 38-42, and 46 were rejected as being anticipated by U.S. Patent No. 5,762,145 to Bennett, referring to Figure 1-9. The Bennett reference discloses a hollow panel with an extinguishant sealed inside. The Bennett reference does not, however, disclose a container that is a single unit configured to conform to a surface of and at least partially enclose the hazardous material container as required by claims 21, 30, and 40. Figure 4 of the Bennett reference may disclose a partially enclosed container, but the enclosure is not a single unit conforming to a surface of and at least partially enclosing the container.

In the "Response to Arguments" portion of the office action, it is asserted that the instant claims only cite "a container" or "a hazardous material container", and that there is no limitation to cite the container is a single unit such as "a single unit container". The previously-submitted amendment, however, clearly adds such a limitation to the claims (e.g. "wherein the shatterable container is a single unit configured to conform to a surface of and at least partially enclose the hazardous material container" in claim 21; "wherein the shatterable container is a single unit and includes at least one surface substantially conforming to a surface of and at least partially enclosing the housing" in claim 30; and "a shatterable container comprising a single unit; at least partially enclosing the housing within the shatterable container" in claim 40). Thus, the applicant submits that the office action is incorrect, and the rejections based upon such incorrect assertions should be withdrawn.

<u>Rejections under 35 USC §103</u>

Claims 24, 33, and 43 stand rejected as being obvious in view of the Rozniecki reference. Likewise, claims 25, 34, and 44 stand rejected as being obvious in view of the Rozniecki reference and U.S. Patent No. 2,911,049 to Crouch. The applicant respectfully traverses the rejections. As discussed above, the Rozniecki reference expressly teaches away from the claimed invention in claims 21, 30, and 40, on which the rejected claims depend. Consequently, the applicant respectfully submits that it is not a mere matter of design choice to arrive at the claimed invention including a shatterable container.

Objected to claims

The applicant notes and appreciates the acknowledgement that claims 26, 37, 45 and 47 would be allowable if rewritten in independent form. In view of the prior amendments, the applicant submits that all claims are now in condition for allowance, including the independent claims and intermediate claims on which claims 26, 35, 45 and 47 now depend.

CONCLUSION

In sum, the applicant respectfully submits that all claims are patentable over the cited references and are in condition for allowance. If there are any questions or concerns, please contact the undersigned at the telephone number indicated below.

Date: 01 JUN 2005

Daniel J. Noblitt (Reg. No. 35,969)

Daniel J. Noblitt
Noblitt & Gilmore, LLC
4800 North Scottsdale Road
Suite 6000
Scottsdale, Arizona 85251
Telephone: 480.994.9859
Facsimile: 480.994.9025

Merriam-Webster OnLine

Merriam-Webster FOR KIDS | Encyclopædia BRITANNICA
Merriam-Webster ONLINE | Merriam-Webster COLLEGIATE® | Merriam-Webster UN

HOME
PREMIUM SERVICES
- M-WCollegiate.com
- M-WUnabridged.com
- Britannica.com
- Multi-User Licenses

DOWNLOADS
WORD OF THE DAY
WORD GAMES
WORD FOR THE WISE
ONLINE STORE
HELP

Merriam-Webster Inc. Company information

Merriam-Webster Online Dictionary

Thesaurus

2 entries found for **shatter**.
To select an entry, click on it.

shatter[1,verb]
earth-shattering
Go

Main Entry: [1]**shat·ter**
Pronunciation: 'sha-t&r
Function: *verb*
Etymology: Middle English *schateren*
transitive senses
1 : to cause to drop or be dispersed
2 a : to break at once into pieces **b** : to damage badly : RUIN
3 : to cause the disruption or annihilation of : DEMOLISH
intransitive senses
1 : to break apart : DISINTEGRATE
2 : to drop off parts (as leaves, petals, or fruit)
- **shat·ter·ing·ly** /-t&-ri[ng]-lE/ *adverb*

For More Information on "shatter" go to Britannica.com

Get the Top 10 Search Results for "shatter"

Merriam-Webste
- Dictionary
- Thesaurus

Glass vs. Acrylic
The Differences Between and the Debate About Glass Aquariums and Acrylic Aquariums

Down to Navigation

Most **aquariums** are made of either glass or acrylic. However, many people don't know what the difference is - except that the acrylic tank is usually much more expensive. Often this results in the impression that the acrylic tank is better, though frequently unaffordable. This is not necessarily true. Both glass and acrylic tanks have their benefits and their drawbacks.

	Glass	Acrylic
Scratching	Glass is very difficult to scratch. Scratching glass usually requires a relatively hard material and a considerably amount of pressure. You can scratch glass if you take a piece of uncoated aquarium gravel or a rock and rub it against the glass, or if you take a piece of metal and deliberately scratch the glass. However this is unlikely.	Acrylic is highly scratchable. Often, despite the best efforts of manufacturers and shippers, the packing materials used to pack acrylic tanks will scratch the tank!. The tank can be scratched by a person brushing it with their clothing, jewelry, purse, back pack, or bag when casually walking past it in the store, and the tank can very easily be scratched when people are moving, loading, or unloading it. The inhabitants of an acrylic aquarium can even scratch the tank themselves, if they have any sharp claws, teeth, or shells... Because acrylic is so easily scratched, it is very important that you only use acrylic safe **algae scrubbers** when **cleaning** your acrylic tank, and that you make sure you do not accidentally pick up any pieces of **aquarium gravel** in the scrub pad when you are using it. Of course, acrylic is also easier to repair when it is scratched. Acrylic polishing kits are available in many places, and these can be used to remove scratches on the outside of the tank. These polishes should not be used on the inside of the aquarium, as they may leave a toxic residue that could make the tank uninhabitable.
Weight	Glass is denser and therefore heavier than acrylic. A glass tank will often weigh 4-10 times as much as an acrylic tank of the same volume.	Acrylic tanks are lighter than glass tanks. This means that if you have to move an acrylic tank for some reason, it will be much easier to do so once the water is all out of it than it will be for its glass counterpart. This also means that an acrylic tank will be less strain on the structure that is supporting it than a glass tank will. However, remember that the majority of the weight of a complete tank is the water and **decorations**, not the tank itself, so you will not save a lot of weight by using an acrylic

		tank rather than a glass one.
Breaking and Cracking	A sharp impact will crack - or in extreme cases, shatter - a glass tank, or at least one of its sides. This will leave you with a mess, no home for your fish, and possibly some significant damage to the area the tank was occupying. However, this is not an every day occurrence. The force required to break a glass tank is still significant, and is almost always the result of otherwise inappropriate behavior.	Though a **VERY** sharp impact will crack or shatter a piece of acrylic, the amount of force needed for this damage is far greater than it is with a glass tank. On the other hand, almost any impact to an acrylic tank will leave a scratch or mark, even those that would not have marked a glass tank.
Shape	Glass is relatively rigid and brittle. Because of this, it is difficult to make fish tanks from glass that are not rectangular in shape. Also, when glass is curved, it has a tendency to bend light, making things on the other side of the curved glass appear larger or smaller than they really are. However, some glass tanks with curved sides are available now.	Acrylic is easily molded and formed into almost any shape that can be described - and some that can't. Acrylic also has less of a tendency to distort things that are behind a curve. Because of these two factors, acrylic aquariums are available in a very large number of shapes - not just rectangular.
Support and Rigidity	Glass can support considerably more than its own weight over distances. Because of this, glass aquariums can be kept on **stands** with an open or incomplete top with little or no risk. However, the aquarium stand still needs to be level and the stand still needs to be strong enough to support the weight of the tank. Also, because of this rigidity, glass tanks require less structural support at the top to keep the tank from flexing or splitting its seams under the weight of the water. Though some bowing of a tank is normal, excessive bowing can lead to split seams or fractured glass.	Acrylic tanks require a **stand** that will support the entire bottom of the tank, or else the bottom of the tank may pul away from the seams under the weight of the water. This is not true in acrylic tanks that have a substantially thicker bottom than would appear necessary. Also, acrylic tanks require much more support across the top of the tank to keep the acrylic from bowing apart and either splitting seams or spilling water.
Strength	The materials required to build a glass tank will be thicker than those required to build an acrylic tank. Though tempered glass does not need to be as thick as non-tempered glass for the same size of tank, the tempered glass will still be thicker than the acrylic necessarily would be for the same tank size. Also tempered glass cannot be drilled to	Acrylic does not need to be as thick to support the same water volume as glass does, and any acrylic tank can be drilled to accommodate an overflow system.

SAN DIEGO PLASTICS, INC.

Sheffield
Plastics, Inc.

SIGN GRADE HIGH-PERFORMANCE POLYCARBONATE SHEET

Makrolon SN

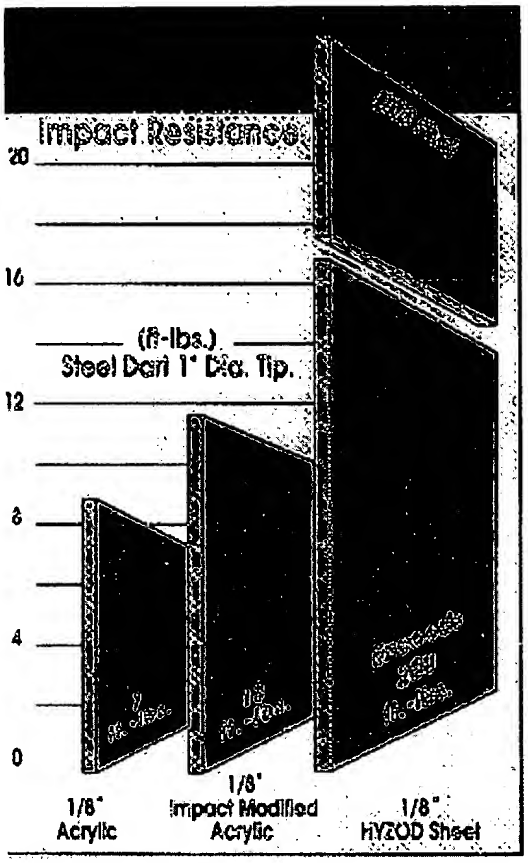
Makrolon SN sheet is often selected as a replacement for both standard and impact-modified acrylic sheet due to its significantly greater impact strength - 30 times stronger than acrylic. And unlike impact-modified acrylic, Makrolon SN maintains its impact strength even at low temperatures. This superior toughness minimizes breakage during production, installation and in use, making Makrolon sheet a cost-effective alternative to acrylic sheet. It also means thinner gauges can be used to achieve lighter weight, higher performance signage. Makrolon SN sheet offers built-in durability for signs that can withstand all kinds of abuse and still look their best for years to come.

SAN DIEGO PLASTICS offers Makrolon SN in a full range of standard clear and white, standard and custom colors, sizes, gauges and patterns to match the requirements of even your most demanding projects.

Makrolon SP - SolarPlus sheet:

The answer when it comes to signs that must withstand intense sunlight.

While all Makrolon SN sheet is UV-stabilized for long life and color retention, signs that are subjected to extreme solar exposure may require the enhanced protection of Sheffield's Makrolon SP sheet. It offers the impact protection of Makrolon polycarbonate sheet coupled with enhanced UV protection. Using advanced extrusion technology, Sheffield Plastics has created a tough product designed to be made into the toughest signs under the sun.



Makrolon AR - Abrasion Resistant sheet:

Polycarbonate's Strength and Glass-like Hardness.

From drive-through menu covers and office park directories to mass transit signs and permanent sign boards - any place where your signs may be subjected to pedestrian contact, vandalism or graffiti - a covering of this new abrasion-resistant sheet is the right option to assure long-lasting protection. The combination of impact strength and surface durability assures resistance to both cyclical cleaning and abuse.

PRODUCT AVAILABILITY Product Group	DESCRIPTIONS	STANDARD SIZES	STANDARD COLORS
HYZOD SN-5100 Sheet	Polished 2 sides	Gauges: 3/32"- 1/4" Length: 100", 125" Width: 52", 64", 75", 100"	Clear, White
HYZOD SN-5100 Reels	Polished 2 sides	Gauges: 3/32"-3/16" Length: 300'-450' * Width: 55", 66", 76", 102"	Clear, White
HYZOD SN-5190 Reels	Matte 1 Side Polished 1 Side	Gauges: 3/32"-3/16" Length: 300'-450' * Width: 55", 66", 76", 102"	Clear, White
HYZOD SP-5100 Sheet (Solar Plus)	Polished Surfaces UV-Coat 1 Side	Gauges: 3/32"-3/16" Length: 100", 125" Width: 52", 64", 75", 100"	Clear, White
HYZOD SP-5100 Reels (Solar Plus)	Polished Surfaces UV-Coat 1 Side	Gauges: 3/32"-3/16" Length: 300'-450' * Width: 55", 66", 76", 102"	Clear, White
HYZOD AR-1000 Sheet (Abrasion-Resistant Coating)	Polished Surfaces AR-Coat 2 Sides	Gauges: 1/8"-1/2" Length: 96" Width: 48", 60"	Clear

* Depending on gauge

PHYSICAL PROPERTIES: PERFORMANCE PLUS

Makrolon polycarbonate sheet provides high impact and heat resistance, in addition to tight thickness tolerance and easy fabrication characteristics. Over the past few years, Sheffield's Makrolon sheet has been utilized in major signage programs in the field and demonstrated its performance in the most demanding sign environments.

TYPICAL PHYSICAL PROPERTIES	HYZOD SN Sheet	UNITS	ASTM
GENERAL			
Specific gravity	1.2	-	D-792
Weight - 1/8" (.125) sheet	.74	lbs./ft2	NA
3/16" (.187) sheet	1.1	lbs./ft2	NA
1/4" (.250) sheet	1.5	lbs./ft2	NA
MECHANICAL			
Tensile Strength, Yield	9,000	psi	D-638
Tensile Strength, Ultimate	9,500	psi	D-638
Tensile Modulus	340,000	psi	D-638
Flexural Strength at 5% Strain	13,500	psi	D-790
Flexural Modulus	345,000	psi	D-790
Izod Impact Strength (0.125" notched)	14-18	ft-lb/in	D-256
THERMAL			
Deflection Temperature (264 psi load)	270°	°F	D-648
(66 psi load)	280°	°F	D-648
Vicat Softening (Rate B)	310-315°	°F	D-1525
Coefficient of Thermal Expansion	3.75 x 10 [illegible]	in / in /°F	D-696
FLAMMABILITY			
Horizontal Burn, AEB	<1	in	D-635
Ignition Temperature			
Self	1077°	°F	D-1929
Flash	872°	°F	

Sheffield Plastics, Inc. together with its European affiliate, ranks as the second largest producer of polycarbonate sheet in the world. The company's emphasis on customer service, technology, quality and cost-competitiveness has made Sheffield a major polycarbonate sheet supplier in markets such as construction, electronics, aviation and transportation. New production facilities are now in place to bring these same advantages to customers in the sign industry.

MATERIAL PREPARATION

GAUGE	DRYING TIME
.093	4 hrs.
.125	6 hrs.
.150	8 hrs.
.187	14 hrs.
.250	24 hrs.
Preheating 250° F	Forming 350° F-400° F

THERMOFORMING

Makrolon polycarbonate sheet can be thermoformed with excellent results on standard equipment using conventional polycarbonate forming techniques. The sheet requires pre-drying to remove excess moisture. Drying guidelines are furnished in this chart.

STRIP HEATING

Strip heating is one way to achieve localized bending of Makrolon sheet for use in signs. Heating both sides at the bend area will help achieve optimum results. Drying is recommended unless the material is .118" or less in thickness.

BONDING AND CEMENTING

In solvent bonding using MDC (methylene dichloride), apply to surfaces to be bonded and hold parts under pressure until cured. Add 10% glacial acetic acid for the best joint appearance.

Urethane adhesives for polycarbonate, which provide optimum impact resistance and flexibility are available from SAN DIEGO PLASTICS, INC.

CUTTING AND SAWING

Makrolon sheet can be cut with most common hand-held and table-mounted saws, including circular saws, routers and band saws using standard blade designs for polycarbonate. For end milling and routing, high rotating speeds or low feed rates are advisable.

SHEARING, PUNCHING AND BLANKING

Unlike acrylic, which will shatter, Makrolon sheet resists cracking or crazing when shearing, punching or blanking, as long as the proper sharp tools are used.

PAINTING AND SILK SCREENING

Makrolon polycarbonate sheet can be painted by silk screening or standard spray techniques using inks and paints commonly available for polycarbonate sheet.

Call today for complete product information!

800/925-4855
619/477-4855

Medical Plastics and Biomaterials Magazine | MPB Article Index

Originally published January 1996

ACRYLIC POLYMERS: A CLEAR FOCUS

W. A. Whitaker III

Optical clarity is an important quality in medical devices or diagnostic equipment that rely on visual inspection and therefore require a high level of transparency. Acrylic, the common name for polymethyl methacrylate (PMMA), has long been used in the manufacture of cuvettes, tubing connectors, speculums, and many other medical devices requiring impact strength, chemical resistance, biocompatibility, and clarity. Acrylic polymers thus occupy a prominent place in the market for clear, disposable plastics--only glass transmits light as well. Acrylic also is commonly used in the manufacture of reading glasses, due to its superior optical qualities.

This article addresses the key properties of acrylic materials and compares them with other thermoplastics competing for a share of the medical market. Benefits to both the manufacturer and the end-user are highlighted, as are applications for which acrylic is well suited and those for which it is not recommended. In addition, the paper discusses acrylic's chemical resistance and performance after sterilization, along with disposal, recycling, and other environmental issues. Design and processing guidelines for manufacturers are also included as is a case study of a specific application.

Overview of Acrylic

Acrylic polymer, derived from the monomer methyl methacrylate (MMA), was first developed more than 60 years ago. Since then, formulations have extended the material's performance range, resulting in varying levels of melt flow, impact resistance, colorability, gamma recovery, and other controlled characteristics. General-purpose acrylic grades contain a comonomer, added during the polymerization process, to facilitate flow during injection molding and extrusion. Specialty grades are formulated to perform in applications requiring high impact strength and heat resistance. UV-light-transmitting formulations are also available, and are specified for certain critical diagnostic equipment in which even slight UV absorption or variation in material flow could be detrimental.

Easily processed and assembled, acrylic has been used in medical and health-care applications since its introduction. One of the first uses of acrylic sheet was for incubators. The first intraocular acrylic prosthesis was implanted in 1955, and ever since acrylic has been used in contact with human tissue. Its biocompatibility led to the adoption of acrylic for aircraft canopies during World War II: pilots suffered fewer infections from shards of acrylic than they had from glass.

The leading applications of acrylic in the medical industry today are for cuvettes and tubing connectors, but it is also used to produce test kits, syringes, luers, blood filters, and drainage wands as well as flowmeters, blood-pump housings, fluid silos, surgical-blade dispensers, incubators, and surgical trays. Acrylic polymers are resistant to many biological and chemical agents. Medical grades of acrylic have passed USP Class VI biological testing procedures and comply with FDA regulation 21 CFR 177.1010.

The use of acrylic polymers in the medical industry has been steadily increasing over the past several years. This is especially noticeable in the area of diagnostics, due to the fact that acrylic is an inert material that does not react with the reagents used in testing. For medical devices, special impact-modified grades formulated to resist breaking and cracking are employed more often than standard grades.

Physical Properties

Acrylic offers light transmittance of 92%--theoretically the maximum obtainable--with particular clarity at lower wavelengths of 270 to 350 nm. For example, acrylic is the

material of choice for disposable cuvettes, used to contain blood and other fluids, through which a spectrum of UV light is passed for analysis. Although quartz glass can be used for the most demanding applications, since it transmits light as low as 220 nm, it is not cost-effective in an application that increasingly favors disposable plastics.

Other prominent physical properties of acrylic include good mechanical strength and dimensional stability, along with high tensile and flexural strength (see Table I). Medical-grade acrylic can be supplied for intricate, thin-wall applications in which maximum optical clarity is required: it offers excellent injection molding flow properties (13 g/10 min) and a tensile strength of 10,600 psi. Acrylic also provides good surface hardness for scratch resistance, an important quality in medical applications.

Because acrylic is a rigid material, standard grades do not provide high impact resistance. Therefore, impact-modified grades--softer and less rigid than standard formulations--are specified for applications that typically require increased toughness. Acrylic is not recommended for applications that demand very high impact resistance or those that put surfaces under high pressure. Acrylic does perform well in electrical applications, due to its insulating nature; an increase in absorbed moisture makes it more conductive.

As temperatures increase, acrylic becomes more flexible and exhibits less flexural strength. Under sustained loading, strain on the material can induce excessive molecular movement that increases with time under load and higher temperatures and results in the phenomenon known as creep that is common to all thermoplastics.

Chemical Resistance

Acrylic is resistant to a wide range of chemicals including salts, bases, aliphatic hydrocarbons, fats and oils, most common gases and inorganic chemicals, dilute mineral and organic acids, and dilute and concentrated solutions of most alkalis. It is attacked by strong acids, chlorinated and aromatic hydrocarbons, ketones, alcohols, ethers, and esters. Of course, the chemicals and other materials to which a molded part will be exposed should be carefully considered before selecting any thermoplastic.

Isopropyl alcohol tends to promote crazing in acrylic, as it

does in many transparent plastics. Some acrylic grades are more alcohol-resistant than others: resistance is typically a function of the molecular weight of the polymer, with higher molecular weight providing better alcohol resistance. Diluted solutions of isopropyl alcohol can be used to wipe down acrylic without adverse reaction. Acrylic copolymers, particularly those with styrene, offer improved chemical resistance but do not transmit light as well as 100% PMMA.

Sterilization Effects

Acceptable sterilization technologies for acrylic are E-beam or gamma irradiation or dry ethylene oxide gas. While gamma sterilization has a tendency to discolor (yellow) most acrylics, this yellowing is temporary and recovery can be complete, with the parts retaining their original integrity. The higher the radiation dosage, the greater the yellowing and the longer the required recovery time. Until recently, when rapid-gamma-recovery formulations were introduced, acrylic took as long as 60 days to recover from the effects of gamma irradiation. This time has been cut to a week for some grades of acrylic. Wet ethylene oxide and steam sterilization methods are not recommended for acrylic.

Material Comparisons

In the area of diagnostics, polystyrene is the closest clear-plastic competitor in optical properties, but its performance at lower light wavelengths does not rival that of acrylic. (Polystyrene begins to absorb light at about 350 nm and, consequently, does not transmit it as well as acrylic.) Polycarbonate, a key material in the medical device area, is normally not used for diagnostic equipment when maximum clarity is a requirement. In nondiagnostic applications, acrylic competes with other clear plastics: these include polystyrene, styrene acrylonitrile (SAN), polyvinyl chloride (PVC), polyethylene terephthalate glycol (PETG), and clear acrylonitrile butadiene styrene (ABS). Each has its own advantages and disadvantages, depending on the application.

Polycarbonate is clearly dominant when strength and toughness are the prime requirements. It tends to be overspecified, especially for large parts whose failure in a medical environment could have severe consequences. Styrene copolymers are starting to gain on polycarbonate because of their toughness, clarity, and moderate pricing; on the downside, they are fairly soft and easily scratched. Acrylic

offers better chemical resistance than polycarbonate. In terms of impact resistance and strength, polycarbonate is tougher, although impact-modified acrylic grades can be used in many applications that specify polycarbonate. Acrylic outperforms polycarbonate in clarity, scratch resistance, and UV transmission, and generally offers better processability, since polycarbonate is prone to problems related to molded-in stress, such as crazing and cracking.

Other tough materials that often are chosen in place of acrylic are clear ABS and clear PETG. ABS is less susceptible to residual molding stresses than polycarbonate, while PETG is less susceptible to chemical attack. But neither ABS nor PETG provides the clarity, scratch resistance, or light transmission of acrylic, and PETG is more difficult to process, tending to warp under adverse molding conditions. PVC is often selected when a flexible material is required, although it does not provide the clarity or scratch resistance of acrylic.

Additional acrylic competitors in the medical market are polystyrene and styrene-containing copolymers such as SAN. These styrenic materials exhibit low melt viscosity and are easy to process, but cannot quite match the performance of acrylic in the areas of clarity and UV transmittance. Polystyrene typically is used for complex parts because of its excellent processability, which reduces the molded-in stresses that can affect light transmission in very complex parts.

Material Selection

The failure of plastic parts can often be traced to mistakes in design, production methods, or material choice. Selecting the material for a particular application involves careful consideration of the end-use environmental conditions and functional requirements of the part. Basing the selection on incorrect criteria can lead to overdesigning the part or specifying a material with properties that exceed the demands of the application, often at the expense of scratch or chemical resistance, clarity, or other desirable qualities. Environmental conditions that figure into the selection include chemicals likely to be encountered, sterilization methods, humidity, temperature, and thermal cycling. Other important factors are mold and part design, processing requirements, and assembly methods.

In selecting the best grade of acrylic to use, these same factors must be considered. Higher-molecular-weight grades

are more resistant to crazing from chemical exposure and mechanical stress, but have lower melt-flow rates. As the level of impact modifier is increased in impact-grade acrylic, other properties such as clarity, light transmission, and tensile strength often diminish.

Processing requirements can be difficult to predict. Flow patterns and mold-filling problems can result from large part surfaces, deep ribs or flanges, asymmetrical geometries, and unbalanced thick and thin sections. Experimenting with several different grades in the prototype tool is recommended. Molds designed for acrylic, ABS, and polycarbonate parts typically accommodate a shrinkage level of 0.006 in./in., allowing for convenient trial runs of acrylic in molds used for ABS or polycarbonate parts. Direct comparison of the parts molded from different materials can help determine the best one for the application.

Processing Considerations

Compared with other polymers, acrylic is relatively easy to process. It can be molded with little or no residual stress and is available in formulations specifically designed for injection molding or extrusion in a wide range of melt-flow rates. Under normal processing conditions, acrylic produces melts that are typically higher in viscosity than those of many other thermoplastic polymers. The higher-molecular-weight grades are generally recommended for extrusion. Because of acrylic's higher- viscosity flow properties, injection molding runners and sprues used to process it need to have larger diameters than those handling polystyrene or polyethylene. Large injection-molded parts or parts with thin-wall geometries may require a high melt-flow rate.

When acrylic is processed in molds built for polycarbonate or polyester, lower injection pressures should be used, as it is less likely to warp than polyesters and is more forgiving in molds not designed with well-balanced gates. Because acrylic has a higher melt viscosity than polystyrene or styrenic alloys, it requires higher injection pressures when selected in place of those materials. Higher clamping forces may also be required. A hygroscopic material, acrylic absorbs water and must be dried prior to molding: if molded while wet, it exhibits moisture splay, leaving streaks, bubbles, and a rough surface on the part.

Typical wall thicknesses for acrylic parts range from 0.040 to

0.500 in. Thicker or thinner parts can be achieved with special designs or processing methods such as injection/ compression molding. Consistency is the key; any changes in thickness should be gradual, and feature radiused edges. Vertical walls should be the same thickness as the rest of the part to avoid pressure variations on the flow front, which can lead to stressed areas and voids caused by trapped air. Moderate residual stress does not affect part performance, but high levels of stress can reduce impact strength and resistance to chemical or heat crazing, and can undermine the dimensional stability of the molded part. Before the part and mold design are completed, a mold-flow analysis should be performed to help avoid costly mistakes and downtime.

Bonding Systems

Acrylic parts can be fastened by chemical bonding, ultrasonic welding, and heat staking. Two types of agents are commonly used to chemically bond acrylic: solvents and polymerizable adhesives. Solvents such as dichloromethane dissolve the surfaces of two acrylic parts, which harden after the solvent evaporates and bond to one another. Solutions of acrylic polymer dissolved in a solvent or methyl-methacrylate monomer work similarly. Two-part polymerizable adhesives contain a viscous acrylic resin base and a liquid catalyst that when mixed together provide a strong joint.

Ultrasonic welding is an efficient method of fusing two parts made from the same material. Both contact (near-field) welding and transmission (far-field) welding can be used for joining acrylic parts. However, materials with different melting points are not good candidates for ultrasonic welding, since even a few degrees difference can result in one material melting before the other reaches its melting point, preventing a fusion between the parts.

Mechanical fastening, which concentrates loads at fastening points, is not recommended for acrylic parts, as the act of drilling holes or torquing fasteners can introduce potentially damaging stress. Holes should be cored out rather than drilled.

Acrylic Case History

Selecting the wrong grade of acrylic can lead to unsatisfactory results. Recently, a manufacturer of a blood-clot analyzer experienced early production problems with several complex

parts molded from a general-purpose grade of acrylic. With the formulation initially chosen, parts developed stress cracks upon ejection from the tools, primarily because of complicated geometries that included sharp corners, edges, and points. Streaking also occurred. It was determined that additional toughness and impact strength were required, in a high-flow grade that would fill the molds.

An impact-modified, gamma- resistant acrylic--which is supplied in injection-grade pellets--was then selected and found to solve some tricky molding problems. High tensile strength and impact resistance were critical; since the parts are used in the assembly of a cassette intended to contain blood, they must be resilient enough to resist cracking if accidentally dropped. Dimensional precision was also important, given the complexity of the processes that occur under pressure inside the cassette during blood analysis. A third requirement was UV transmissability, which was necessary for curing the adhesive used in the cassette assembly.

Molded from the impact-modified grade, the cassette parts have proven to be sufficiently durable, both during fabrication and in use. The acrylic material provides the requisite impact strength as well as a high degree of optical clarity and scratch resistance, and presents a pleasing, glossy surface finish. After use in the blood-clot analyzer, the disposable cassettes are incinerated with other medical waste.

Disposal and Recycling

Acrylic burns extremely clean, providing virtually smokeless combustion with end products of carbon dioxide and water (per ASTM E 662). In addition, the material offers superior recyclability: acrylic can be reground and reused, which results in less material waste during molding.

Another characteristic of acrylic is its ability to be depolymerized back to its monomer, thoroughly purged of impurities, and repolymerized back into PMMA. Commercial processing facilities set up for this process typically use a molten lead bath to vaporize the acrylic material. The vapors are captured and recondensed into MMA, while eliminating any biomedical waste. This is a true recycling process, taking the polymer back to its monomer, whereas most other "recycling" processes involve crushing the material and using it in applications with lower specifications. For environmental

reasons, commercial molten lead baths are no longer operated in the United States, but do exist in England, India, and several other countries.

Conclusion

Used in medical applications for many years, acrylic offers a number of advantages compared with other clear thermoplastic materials traditionally specified for diagnostic equipment and medical devices. Benefits include unsurpassed clarity, superior toughness, rapid gamma recovery, excellent UV-light transmittance, biocompatibility, and good chemical and scratch resistance. Acrylic is easily processed and assembled and offers the potential to be recycled back to its monomer and used again, an important property as the pressure to recycle increases.

Acrylic resin can be custom formulated to meet the requirements of a broad range of medical applications. Since it can be processed in molds designed for polycarbonate and other thermoplastics, manufacturers using those materials should consider trial runs with acrylic. Direct comparisons between parts molded with acrylic and with competing thermoplastics may reveal potential cost savings as well as unexpected side benefits such as improved surface finish, transparency, processing, and part performance.

W. A. Whitaker III *is marketing manager for the polymer division of ICI Acrylics, Inc. (Memphis, TN). At ICI since 1972, he has held a number of positions within the company, including sales, technical services, market development, and commercial management.*

Comments about this article?
Post them in our Members' Discussion Forums.

productfocus

See-through plastic installation guidelines

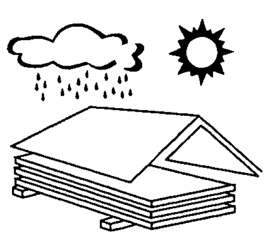
SEE-THROUGHS

by Tami Churchill Voss

Polycarbonate glazing panels are available in many forms, such as multiwall, corrugated and solid sheets. You can always expect high light transmission, light in weight, high flexibility, excellent impact strength, UV protection against yellowing and easy fabrication guidelines from polycarbonate panels. *Tip:* Polycarbonate has an impact strength that is 200 times stronger than glass and 10 times stronger than acrylic.

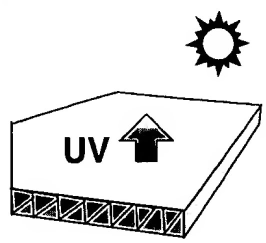
Coverlite™ solid polycarbonate glazing by American Louver Plastics Corporation.

For storing polycarbonate glazing panels at the job site, make sure to keep the sheets in a dry area out of direct sunlight or heat. Exposing the panels to heat from the sun can cause the protective film to adhere to the sheet surface making it difficult to remove. *Tip:* If you are having trouble peeling off the protective film, wait for the temperature to drop which will cool off the sheet and should make it easier to remove.



Structured polycarbonate sheets must be padded and packaged in good condition during storage and transportation. Protect sheets from direct sunlight and shelter from rain and snow.

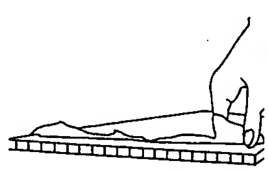
Always remember to make sure the UV protected side of the sheet is facing out on the exterior of the application. Most all of the polycarbonate manufacturers either put a sticker on the UV protected side or they will print it on the protective film masking. *Tip:* If you have removed the film and are not sure which is the exterior side of the panel, take a "black light" in a dark area and shine it on the surfaces of the sheet. The side that glows a bright blue color is your UV protected surface.



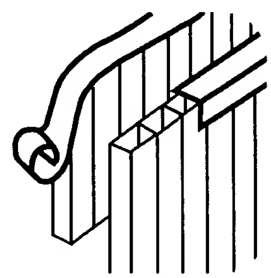
The UV-protected side of structured polycarbonate sheet is covered with printed film and must face toward the sun.

Never remove the entire sheet of protective film from your polycarbonate panel until after installation. The film is put on the polycarbonate to protect it and to identify the UV stabilized side of the sheet. Without the masking, it is very hard to tell which side is the UV protected surface. It is recommended that the film is removed about 2" from the edges around the sheet during installation. Finish with removal of the entire sheet of film immediately after the panel has been installed. *Tip:* Remove the film after each panel is installed, not after the project is completed.

Remove approximately 2" of film from all sheet edges before installing. Remove all film immediately after the panel is installed.



During fabrication and installation, make sure to drill screw holes 5/64" larger than the screw diameter allowing for thermal expansion. This extra space will provide for seasonal temperature fluctuation which causes the sheet to expand and contract. When cutting the polycarbonate panels, use a circular saw with a fine tooth blade (minimum 10 teeth per inch). On thinner gauge sheets, a razor knife can be used to cut the sheet. Remember to cut on both sides of the sheet if you use a razor knife. Always point fasten your sheets at least 1-1/2" in from the sheet edge. On multiwall polycarbonate panels, the ends of the sheet need to be sealed with either a polycarbonate U profile or perforated aluminum tape. Sealing the end of the sheets keeps dirt and debris out of the flutes. *Tip:* Compressed air may be used to clean debris from the flutes.

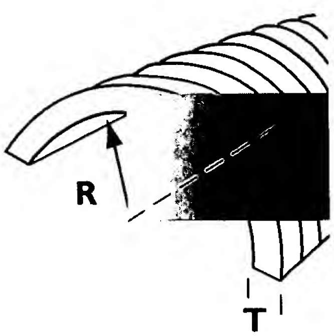


Structured polycarbonate sheets must always be installed with ribs positioned vertically. Seal ends with perforated aluminum tape and/or a perforated U profile.

Coverlite™ 16 mm multiwall polycarbonate on the roof and .118 solid polycarbonate glazing on the end walls by American Louver Plastics Corporation.

Coverlite™ multiwall 16 mm polycarbonate glazing by American Louver Plastics Corporation covers a residential sun room.

If the application requires bending, polycarbonate can easily be cold formed, thermoformed and vacuum formed. The radius of the curve on cold forming depends on the thickness of your panel. Check with the manufacturer for "minimum bending radius" and forming guidelines. Each polycarbonate panel from solid sheet to multiwall sheet will require slightly different forming guidelines depending on the sheet configuration. *Tip:* On multiwall panels, make sure to place the ribs running the length of the arch, not parallel to the center of the arch.



When cold bending structured polycarbonate sheet, place the ribs following the desired arch. (Do not place the ribs parallel to the center of the arch, shown dashed line.) The radius of the curve must be more than 175 times the sheet thickness. Do not walk on structured polycarbonate sheet at any time.

After installation, panels should be washed. Polycarbonate can scratch easily. Never rub abrasive particles on the sheet surface. Use a mild soap solution with a soft cloth to loosen any dirt or debris and then rinse with clean water. Do not use any harsh chemicals on the sheet surface as it can compromise the integrity of the UV protection and strength of the sheet. Call the manufacturer for a list of chemicals compatible with polycarbonate. *Tip:* Use mild dishwashing detergent as your cleaning solution.

Conclusion

Polycarbonate panels in solid, multiwall and corrugated can be used in various applications from interior projects like ceiling panels or office partitions to exterior building materials used in skylights, walkways, greenhouse glazing and insulated roofing. The possibilities for polycarbonate are endless! Make polycarbonate your material of choice on your next glazing project. ■

Tami Churchill Voss is vice president of American Louver Plastics Corporation. For further information, contact American Louver Plastics Corporation, 7700 North Austin Avenue, Skokie, IL 60077 USA; (847) 470-0645, fax (847) 470-0420, e-mail: alpctami@aol.com, www.americanlouverplastics.com.

Table 1 – Property[1] Comparisons of Selected Engineering Thermoplastics

Thermoplastics	Notched Izod			Yield Strength			Tensile Modulus			Flexural Strength			Flexural Modulus			HDT @ 1.8 MPa			Light Transmittance
	S.I. J/m	English ft-lb/in	Metric kg cm/cm	S.I. MPa	English psi	Metric kg/cm²	S.I. GPa	English psi	Metric kg/cm²	S.I. MPa	English psi	Metric kg/cm²	S.I. GPa	English psi	Metric kg/cm²	S.I. °C	English °F	Metric °C	S.I./English/Metric %
MAGNUM[4] 342EZ ABS	160.0	3.0	16.0	40	5,700	400	2.2	320,000	22,500	60	9,900	690	2.2	320,000	22,400	80	175	80	opaque
MAGNUM 9020 ABS	320	6.0	32.5	40	5,700	400	2.2	320,000	22,500	65	9,600	670	2.3	330,000	23,500	100	220	100	opaque
Acetal	65 - 120	1.0 - 2.0	6.5 - 12.0	70	9,700	680	3.6	520,000	36,500	95	14,000	980	2.8	407,000	28,600	125	260	125	opaque
Acrylic	40 - 130	0.8 - 2.5	4.0 - 13.0	40	5,500	340	1.7	250,000	17,500	60	9,000	630	1.7	250,000	17,300	80	180	80	90
Amor Nylon	70	10	7	65	9,700	680	2.8	410,000	28,500	90	13,200	940	2.6	378,000	26,500	125	255	125	opaque
Nylon 6,6	110	2.0	1	45	6,500	460	1.3	190,000	13,500	40	6,100	430	1.3	189,000	13,300	75	170	75	opaque
Polybutylene Terephthalate	40 - 60	0.8-1.0	4.0 - 6.0	55	8,100	570	1.9	280,000	19,500	100	15,000	1,050	2.5	360,000	25,500	50-80	120-175	50-80	opaque
PULSE 830 PC/ABS	640	12	65	50	7,700	540	2.1	310,000	22,000	80	12,000	850	2.3	330,000	23,500	120	250	120	opaque
CALIBRE[4] 300-15 Polycarbonate[3]	850	16	85	60	9,000	630	2.2	320,000	22,500	100	14,100	990	2.4	350,000	24,500	125	260	125	90
STYRON[4] 498 Polystyrene	70	1.0	7.0	25	3,800	270	2.2	320,000	22,500	50	7,500	530	2.1	305,000	21,400	90	190	90	opaque
STYRON 685 Polystyrene	10	0.25	1.4	45	6,400	450	3.2	460,000	32,500	85	12,300	870	3.3	485,000	34,000	100	220	100	90
STYRON XL-8023VC Polystyrene	110	2.0	12	30	4,800	340	2.3	330,000	23,500	65	9,400	660	2.4	380,000	24,500	80	170	80	opaque
STYRON 6075 Polystyrene[2]	110	2.0	12	25	3,600	250	2.1	305,000	21,000	50	6,800	480	2.3	330,000	23,500	90	200	90	opaque
Polysulfone	70	1.0	7	70	10,100	710	2.5	360,000	25,500	100	15,400	1,100	2.7	390,000	27,500	175	350	175	75
ISOPLAST[4] 101 Polyurethane	1,200	22.0	120	50	7,000	490	1.5	220,000	15,000	70	9,800	690	1.8	260,000	18,400	80	170	80	opaque
ISOPLAST 101-LGF40-NAT Polyurethane	430	8.0	40	190	27,000	1,900	11.7	1,700,000	119,000	300	45,000	3,200	10.3	1,500,000	105,100	90	200	90	opaque
Polyphenylene Oxide (impact modified)	320-330	6.0 - 6.2	32 - 33	50	7,500	530	2.4	350,000	25,000	70	10,000	700	2.4	350,00	24,500	90-135	190-275	90-135	opaque
TYRIL[4] 880B SAN	27	0.5	2.8	82	11,900	840	3.9	570,000	40,000	100	16,000	1,100	4	580,000	40,800	100	220	100	87

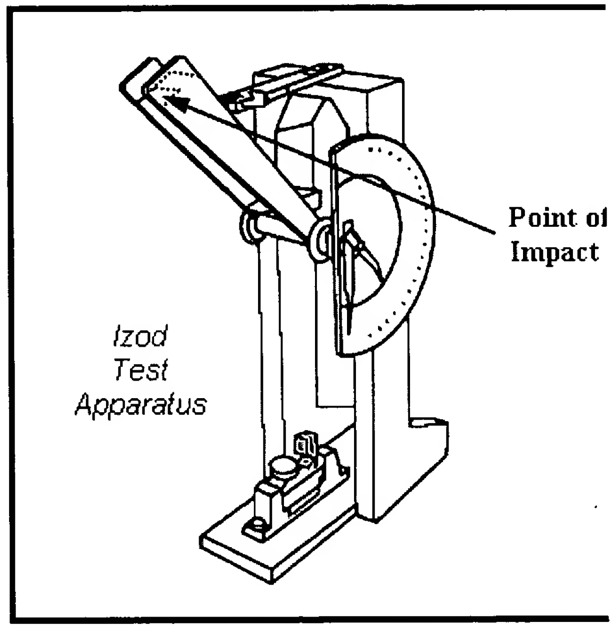
[1]Typical property values; not to be construed as specifications
[2]Ignition resistant resin
[3]General purpose resin, no incorporated additives, 15 Melt Flow Rate
[4]Trademark of The Dow Chemical Company

Izod = measure of impact strength

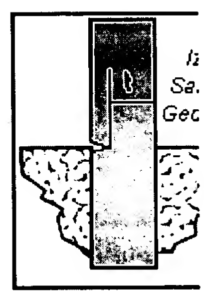
Izod Impact Strength Testing of Plastics

Several methods are used to measure the impact resistance of plastics - Izod, Charpy, Gardner, tensile impact, ai many others. These impact tests allow designers to compare the relative impact resistance under laboratory cond and, consequently, are often used for material selection or quality control. However, these tests generally don't trε into explicit design parameters. The Izod impact test is the most common test in the USA. The figure below, from Quadrant Engineering Plastic Products, depicts the Izod impact strength test apparatus.

ASTM D256:
A pendulum swings on its track and strikes a notched, cantelevered plastic sample. The energy lost (required to break the sample) as the pedulum continues on its path is measured from the distance of its follow through. Sample thickness is usually 1/8 in. (3.2 mm) but may be up to 1/2 in. (12.3 mm).



The test method generally utilized in the USA is ASTM D256. The result of the Izod test is reported in energy lost per unit of specimen thickness (such as ft-lb/in or J/cm) at the notch ('t' in graphic at right). Additionally, the results may be reported as energy lost per unit cross-sectional area at the notch (J/m² or ft-lb/in²). In Europe, ISO 180 methods are used and results reported based only on the cross-sectional area at the notch (J/m²).



Materials that are sensitive to the stress concentrations at the notch ('notch-sensitive') will perform poorly in the nc izod test. Engineers use this knowledge to avoid designs with high stress concentrations such as sharp corners oı cutouts. Unnotched specimens are also frequently tested via the Izod impact method to give a more complete understanding of impact resistance.

Izod impact tests are commonly run at low temperatures - down to -40°F (-40°C) or occasionally lower - to help gε the impact resistance of plastics used in cold environments.

The impact resistance of a given grade of polymer is a function of the base resin plus the presence of any impact modifiers (such as elastomers) and reinforcing agents that may be added by the manufacturer/compounder. Environmental factors, in additional to temperature, also play a role in impact resistance. For example, nylons

(polyamides) generally experience higher impact strength in the conditioned state (in equilibrium with atmospheric moisture) than in a dry-as-molded state.

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☑ FADED TEXT OR DRAWING
- ☑ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☑ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☑ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: ______________________________

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.